IMPROVEMENTS TO SENSORS FOR MEASURING AT LEAST ONE PHYSICAL PARAMETER OF A FLUID FLOW, AND IN PARTICULAR IMPROVEMENTS TO DE-ICED SENSORS OF TOTAL AIR TEMPERATURE

The present invention relates to a sensor for measuring at least physical parameter of a fluid flow, and in particular it relates to a de-iced sensor of total air temperature.

A particularly advantageous application of the invention lies in the field of aviation for measuring total air temperature admitted to aircraft engines, and/or outside aircraft.

Numerous de-iced sensors of total air temperature are already known.

Conventionally, as shown in Figures 1 and 2, they comprise an air intake 1 fitted on a streamlined body 2 having a profile of the aircraft wing type.

A duct 3 is provided in the streamlined body 2 and allows the flow of fluid having a physical parameter that is to be measured to be put into communication with the air intake 1 via an inertial separation zone 4.

This zone 4 serves to separate elements of large mass (liquid, frost, sand, ...) from the remainder of the gas by centrifuging, said elements being evacuated from the sensor via an ejection zone 5 opposite from the air intake 1.

In order to avoid phenomena of fluid separating in the inertial separation zone, holes 6 are made through the wall thereof on its side opposite from the ejection zone 5, and in communication with the outside via a chamber 7 which extends transversely relative to the streamlined body 2.

The pressure difference that exists between the inside and the outside of the sensor enables the boundary layer to be sucked in through the holes 6.

The assembly comprising the air intake 1, the streamlined body 2, the duct 3, the inertial separation zone 4, and the ejection zone 5 is electrically de-iced by heater resistor elements positioned in grooves 8 formed in the walls of the sensor.

An element 9 forming a sensing element extends inside the duct 3.

By way of example, the element 9 is a resistance thermometer that is thermally insulated from the streamlined body 2.

The streamlined body 2 also referred to as a "mast" is fitted to a fixing flange 11 which is of generally plane shape (for example a disk), extending perpendicularly to the axis of the body 2 and of the duct 3.

A connection socket 10 is fitted to the fixing flange 11 on its side opposite from the streamlined body 2.

Generally, as shown in Figure 2, the air intake 1 is of rectangular inside section and the same applies, at least over a certain fraction, to the duct 3 which is connected to the air intake 1.

The Applicant has recently proposed, in particular in its application WO 01/88496, a sensor structure in which the air intake has semi-circular or semi-elliptical shape. It has been shown that such a shape makes it possible to withstand icing conditions that are more severe than is possible with sensors having air intake sections that are rectangular.

The object of the invention is to propose a sensor presenting behavior that is further improved under icing conditions, but without degrading measurement performance under dry conditions.

In this end, the invention proposes a sensor for measuring a physical parameter of a fluid comprising a fluid intake fitted to a streamlined body; a duct provided in said streamlined body to enable fluid flow, said duct communicating with said fluid intake; a sensing element disposed inside said duct, characterized in that the streamlined body extends with a longitudinal axis inclined relative to the fluid flow in a direction other than perpendicularly relative to said fluid flow.

In particular, the invention proposes a sensor comprising a fixing flange having a bearing surface defining a fixing plane for the sensor, wherein the streamlined body is inclined relative to the fixing plane and has a longitudinal axis extending other than perpendicular relative to said plane.

As will be explained in more details later, such an inclined structure presents numerous advantages: increase of the de-icing speed of the sensor; optimization of the inertial separation; increase of the section; better suction efficiency.

Other characteristics and advantages of the invention appear further from the following description which is illustrative and non-limiting and which should be read with reference to the accompanying drawings, in which:

· Figures 1 and 2, described above, are diagrammatic section and perspective views of a prior art de-iced sensor for measuring total air temperature;

· Figure 3 is a section view showing one possible embodiment of the invention;

· Figure 4 is a side view of the embodiment shown in Figure 3;

· Figures 5 and 6 are perspective views showing two examples of air intake shapes;

· Figure 7 is a diagrammatic perspective view of a sensor constituting a possible embodiment of the invention, this perspective view showing one possible shape for the ejection section of the sensor.

The sensors shown in Figure 3 et seq. also have an air intake 1 supported by a streamlined body or "mast" 2 and opening out into a duct 3 which extends inside said mast 2, the duct 3 receiving a sensing element 9.

The streamlined body or "mast" 2 extends from a fixing flange 11.

The fixing flange presents, in particular, a bearing surface 11a for bearing against the part on which the sensor is to be fixed (e.g. a portion of fuselage), this bearing surface defining a fixing plane for the sensor.

This mast 2 and the fixing flange 11 may be manufactured as a single-piece in foundry, which enables increase of the mechanical aspect of the assembly.

The sensor consisting of the streamlined body 2 and the fluid intake 1 has the particularity to extend in an inclined way relative to the air or fluid flow (as schematically represented by arrows on figure 3), instead of being perpendicular relative to said flow.

More precisely, the sensor then extends so that the opening of the intake 1 lies in the fluid flow with the mast also being in the fluid, its main midplane being parallel to the flow direction thereof, the axis of said mast (i.e. the axis of the duct 3 and of the sensing element 9 referenced A in Figure 3) being inclined relative to the fluid flow and being disposed at a certain angle relative to a direction that extends in said midplane perpendicularly to the fluid flow and to the fixing plane defined by the bearing surface 11a.

This inclination is "backwards", the head of the sensor, i.e. the air intake 1, being further back than the portion of the mast 2 that is furthest away therefrom relative to the fluid flow direction.

The angle between the axis A of the mast 2 and the above-mentioned perpendicular direction (angle α in Figure 3) is about 5° to 15°.

It has to be noted that the flow direction of the ejection zone 5 (axis B on figure 3) is perpendicular relative to the axis of the sensor 2, and is thus inclined relative to the fluid flow direction.

Such an inclined structure presents numerous advantages.

In particular, it substantially increases the speed of de-icing of the sensor.

It further optimizes the inertial separation in de-icing operation.

It further increases the ejection diameter without degrading the performances under dry conditions

It substantially betters the suction efficiency of the boundary layer.

As shown more particularly in Figures 5 and 6, the air intake 1 is of a shape that is rounded, at least in part.

In the example shown in Figure 5, the air intake 1 is defined by a top portion 1a of inside shape that is substantially cylindrical, and by a bottom wall 1b that is plane in shape, extending between the edge of the opening to the air intake 1 and the inertial zone 4, where the terms "top" and "bottom" should be understood herein as being relative to the main axis of the body 2 with the fixing flange 11 being taken as being at the bottom end and the air intake at the top end.

In the example shown in Figure 6, the air intake 1 is defined by a bottom plane surface 1b and a top plane surface 1c, connected together by lateral surfaces 1d of a cylindrical global shape.

The duct 3 also presents a rounded shape, at least in part.

The use of rounded shapes for the air intake 1 and/or for the duct 3 has the advantage of enabling the inside surface area of the sensor on which ice might be deposited to be reduced, and of eliminating zones in which the flow section of the air or fluid to be measured changes, thereby eliminating the dead zones that are generated in corners.

For given de-icing power, these shapes enable icing conditions to be withstood that are more severe than is possible with conventional sensors having an air intake of rectangular-shaped section; they also make it possible to comply with the latest developments in aviation standards. In particular, for identical icing conditions, the de-icing power required is reduced by 10% to 20% compared with prior art sensors.

Nevertheless, it should be observed that air intakes of the type shown in Figure 6 are more particularly preferred: in particular the plane top surface

1c makes it possible to ensure an internal compression ratio that is sufficient to ensure good efficiency for the suction system, regardless of the external flow rate.

In the example shown in Figure 5, as in Figure 6 , the plane bottom surface 1b of the air intake 1 does not have the suction holes that are usually provided for systems for sucking in boundary layers, but instead has slots 12 which extend perpendicularly to the flow direction of the stream through the air intake.

These slots 12 serve to limit development of a thermal boundary layer inside the sensor and also inside the duct 3 which contains the sensing element, because:

· of an increase in suction efficiency due to a larger effective section area; and

· of an absence of flow lines being deflected, said slots making it possible for the flow to present a certain amount of width (flow 2D in Figure 8b) unlike the suction system based on holes (Figure 8a).

A particularly advantageous application of this improvement – which could be used independently of the fact that the sensor is inclined – lies with a sensor presenting an angle of incidence relative to the flow direction of the stream that is large (angle of incidence greater than 5°). The angular sensitivity when the heating system is active is then reduced by an amount lying in the range 20% to 50%.

Furthermore, these suction slots 12 open out into a boundary layers separation chamber 7 which is defined firstly by the wall 1b and secondly by a wall 13 which extends in an inclined way relative to the wall 1b and relative to the fluid flow to the curved wall that delimits the inertial separation zone 4 and said chamber 7.

This inclined wall 13 enables the suction capacity of the slots 12 to be increased by optimizing the pressure difference between the inside of the sensor and the openings defined by the shape of the chamber 7, with this being achieved by generating a marginal vortex on the edges of the wall 13. This reduces the error associated with the heating system at low flow rate.

It has further to be noted that the fluid intake 1 and the interior duct 3 are manufactures as a single piece in foundry, which enables separation of the fluid passage sections from the assembling sections of the sensor.

This allows a better checking of the critical dimensions inside the sensor, and thus a better repetitiveness of the measuring performance from a sensor to another, and thus at reduced cost.

Furthermore, the ejection section of the zone 5 is an important feature in the inertial separation of particles that penetrate into the sensor and intervenes directly in the sensor ability to ingest ice crystals and frost.

It has to be noted that the inclined structure of the sensor enables a passage section adapted to the high concentrations of crystals that are met today in modern airplanes, which thus responds to the last evolutions of aeronautics standards.

The sensing element 9 is constituted by two main portions of cylindrical shape (a ceramic tube and a support mandrel). These shapes enable energy to be exchanged in optimum manner with the fluid under measurement and consequently serve to reduce the error caused by heat transfer by conduction between the sensor and the sensing element. This effect is amplified by using a thermally insulating ceramic for the support mandrel. Ceramics are particularly advantageous for manufacturing the sensing element because of their mechanical characteristics (resistance to fatigue).

A thermal screen 14 arranged between the sensor and the sub-assembly forming the sensing element constitutes a thermal barrier against the radiation emitted by the body of the sensor.

This results in a major increase of the measuring precision, in particular when the thermal exchanges with the measured fluid are low (low land speed or very high altitude flight).